

WE CLAIM:

- 1 1. A method for ultrasonically detecting vibration of a target, comprising the steps of:
2 causing a stream of a fluid to flow from an outlet in a chamber to the target;
3 providing an ultrasonic carrier beam of a predetermined frequency in the fluid,
4 said carrier beam being propagated along the fluid stream to the target;
5 converting a reflected ultrasonic beam to a return electrical signal; and
6 demodulating the return electrical signal so as to provide a measure of a
7 vibrational characteristic of the target.
- 1 2. The method of Claim 1, wherein the steps of providing an ultrasonic carrier beam and of
2 converting a reflected ultrasonic beam to a return electrical signal are performed by means of at
3 least one transducer in contact with the fluid in the chamber.
- 1 3. The method of Claim 2, further comprising the steps of:
2 measuring a noise signal produced by vibration of at least one transducer; and
3 cancelling the noise signal from the return electrical signal.
- 1 4. The method of Claim 1, wherein the target comprises a cutting tool or a workpiece.
- 1 5. The method of Claim 1, wherein the ultrasonic carrier beam is a focused ultrasonic beam.
- 1 6. The method of Claim 1, wherein the predetermined frequency is between 100 kHz and 10
2 MHz.
- 1 7. The method of Claim 1, wherein the ultrasonic carrier beam is a continuous ultrasonic
2 beam.
- 1 8. The method of Claim 1, wherein the stream of the fluid is caused to flow from the
2 chamber to the target by means of a fluid source in combination with a means selected from the
3 group consisting of mechanical pump, hydraulic pressure, gas pressure, and gravity.

1 9. The method of Claim 1, wherein the vibrational characteristic is selected from the group
2 consisting of surface displacement and surface velocity.

1 10. The method of Claim 1, further comprising the step of:
2 introducing an electrical time delay into the signal path via analog electronic
3 means or via a separate ultrasonic delay line,
4 whereby a signal enhancement is provided.

1 11. The method of Claim 1, further comprising the step of:
2 calibrating the vibrational characteristic of the target by means of a phase modulator or a
3 frequency modulator.

1 12. A device for ultrasonically detecting vibration of a target, comprising:
2 a fluid;
3 a chamber containing the fluid and having an outlet through which a stream of the
4 fluid is caused to flow from the chamber to the target;
5 a fluid source in fluid communication with said chamber;
6 a means for causing the fluid to flow from said fluid source through said chamber
7 to the target;
8 a driver for providing an electrical signal of a predetermined frequency;
9 a transducer in contact with the fluid in the chamber and driven by said driver to
10 generate an ultrasonic carrier beam that is propagated along the stream of the fluid to the
11 target, wherein said transducer also detects a reflected ultrasonic beam from the target
12 and generates a return electrical signal;
13 a directional coupler, disposed between said driver and said transducer; and
14 a demodulator for processing the return electrical signal so as to provide a
15 measure of a vibrational characteristic of the target.

1 13. The device of Claim 12, wherein said means for causing the fluid to flow from said fluid
2 source through said chamber to the target is selected from the group consisting of mechanical
3 pump, hydraulic pressure, gas pressure and gravity.

- 1 14. The device of Claim 12, further comprising a baffle within said chamber for providing
2 laminar flow of the fluid.
- 1 15. The device of Claim 12, further comprising a contact accelerometer for detecting
2 vibration of said transducer.
- 1 16. The device of Claim 12, further comprising a confinement tube for the stream of the
2 fluid.
- 1 17. The device of Claim 12, further comprising a protective tube for the stream of the fluid.
- 1 18. The device of Claim 12, further comprising a phase modulator or a frequency modulator
2 for calibrating the demodulator.
- 1 19. A device for ultrasonically detecting vibration of a target, comprising:
2 a fluid;
3 a chamber containing the fluid and having an outlet through which a stream of the
4 fluid is caused to flow from the chamber to the target;
5 a fluid source in fluid communication with said chamber;
6 a means for causing the fluid to flow from said fluid source through said chamber
7 to the target;
8 a driver for providing an electrical signal of a predetermined frequency;
9 a first transducer in contact with the fluid in the chamber and driven by said driver
10 to generate an ultrasonic carrier beam that is propagated along the stream of the fluid to
11 the target;
12 a second transducer that detects a reflected ultrasonic beam from the target and
13 generates a return electrical signal; and
14 a demodulator for processing the return electrical signal so as to provide a
15 measure of a vibrational characteristic of the target.

1 20. The device of Claim 19, wherein said means for causing the fluid to flow from said fluid
2 source through said chamber to the target is selected from the group consisting of mechanical
3 pump, hydraulic pressure, gas pressure and gravity.

1 21. The device of Claim 19, further comprising a baffle within said chamber for providing
2 laminar flow of the fluid.

1 22. The device of Claim 19, further comprising a contact accelerometer for detecting
2 vibration of said transducer.

1 23. The device of Claim 19, further comprising a confinement tube for the stream of the
2 fluid.

1 24. The device of Claim 19, further comprising a protective tube for the stream of the fluid.

1 25. The device of Claim 19, further comprising a phase modulator or a frequency modulator
2 for calibrating the demodulator.

1 26. A device for ultrasonically detecting vibration of a target, comprising:
2 a fluid;
3 a chamber containing the fluid and having an outlet through which a stream of the
4 fluid is caused to flow from the chamber to the target;
5 a fluid source in fluid communication with said chamber;
6 a fluid pump;
7 a driver for providing an electrical signal of a predetermined frequency;
8 a transducer in contact with the fluid in the chamber and driven by said driver to
9 generate an ultrasonic carrier beam that is propagated along the stream of the fluid to the
10 target, wherein said transducer also detects a reflected ultrasonic beam from the target
11 and generates a return electrical signal;
12 a directional coupler, disposed between said driver and said transducer; and

- 13 a demodulator for processing the return electrical signal so as to provide a
14 measure of a vibrational characteristic of the target.